Hawking radiation as the cause of an increase in the mass of a black hole.

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Using the theory of relativity, it can be shown that if Hawking radiation exists, then it will lead to an increase in the mass of the black hole. The strict conclusion from this statement is rather trivial. But, before the conclusion, let us consider the Hawking radiation in more detail.

"Hawking radiation is a hypothetical process of emission by a black hole of various elementary particles, mainly photons; named after Stephen Hawking. Hawking radiation is the main argument of scientists regarding the decay (evaporation) of small black holes...

V. Gribov in a discussion with Ya. Zeldovich insisted that due to quantum tunneling black holes should emit particles.

Even before the publication of his work, Hawking visited Moscow in 1973, where he met with Soviet scientists Yakov Zeldovich and Alexei Starobinsky. They demonstrated to Hawking that, according to the uncertainty principle of quantum mechanics, rotating black holes should generate and emit particles...

Evaporation of a black hole is a quantum process...

In the case of a black hole, the situation is as follows.

...the physical vacuum is filled with constantly emerging and disappearing fluctuations of various fields (one might say "virtual particles").

In the field of external forces, the dynamics of these fluctuations changes, and if the forces are large enough, particle-antiparticle pairs can be generated directly from the vacuum. Such processes also occur near (but still outside) the black hole event horizon.

In this case, it is possible that one of the particles (no matter which one) falls into the black hole, while the other escapes and is available for observation.

It follows from the law of conservation of energy that such a particle from the generated virtual pair "falling" beyond the event horizon should have negative energy, since the "escaped" particle, available to a distant observer, has positive energy..." [1].

Further, usually, the explanation follows that since the particle "falling" beyond the event horizon of the black hole (that is, into a black hole) has negative energy, the energy, and hence the mass, of the black hole decreases.

But this is not the case. Due to the fact that in relativistic mechanics the energy of a particle or body can only be a positive quantity directly related to the mass by the corresponding equation of A. Einstein:

$$E^2 = (p * c)^2 + (m * c^2)^2$$

By elementary transformations we get:

$$m = (E^2 - (p * c)^2)^{0.5} / c^2$$

From the last expression, it is obvious that the mass, at any energy, will be positive. For this reason, particles and antiparticles have positive mass.

Recall that according to Einstein, the mass of a body is simply a measure of its energy content [2]. Therefore, taking into account the principle of equivalence, we can say that if there is energy, then the mass will always be positive, since it must express a certain measure of inertia of a given energy. Momentum is essentially a negative measure of energy inertia.

And that is precisely why, when a particle, which has “negative” energy, falls into a black hole, the mass of the black hole will only increase. That is, even small black holes will constantly increase their mass by emitting Hawking radiation. Therefore, we will never experimentally detect the evaporation of black holes. Even if there is Hawking radiation.

Basically, the real universe confirms our findings. According to Einstein's general relativity, during the formation of the Universe, primordial black holes with a small mass (10^{12} kg) could be born, which in our time should finish evaporating, with an explosion. Nothing of the kind was recorded.

To understand why, in relativistic mechanics, the energy of a free particle (or body) can only be positive, I will quote [3]:

“ …$p = (m * v) / (1 - v^2 / c^2)^{0.5}$ (9.1)

...we get:

$$E = (m * c^2) / (1 - v^2 / c^2)^{0.5} \qquad (9.4)$$

This very important formula shows, in particular, that in relativistic mechanics the energy of a free particle does not vanish at $v = 0$, but remains a finite quantity equal to

$$E = m * c^2. \qquad (9.5)$$

It is called the rest energy of the particle.

At low velocities ($v << c$), we have, expanding (9.4) in powers of v/c:

$$E \approx m * c^2 + (m * v^2) / 2,$$

that is, minus the rest energy, the classical expression for the kinetic energy of a particle.

Let us emphasize that although we are talking here about a “particle”, its “elementary nature” is not used anywhere. Therefore, the formulas obtained are equally applicable to any complex body, consisting of many particles, and under m should be understood as the total mass of the body, and under v - the speed of its movement as a whole. In particular, formula (9.5) is also valid for any resting body as a whole.

Pay attention to the fact that the energy of a free body (that is, the energy of any closed system) in relativistic mechanics turns out to be a completely definite, always positive quantity, directly related to the mass of the body. Recall that in classical mechanics the energy of a body is determined only up to an arbitrary additive constant, and can be both positive and negative...

By squaring expressions (9.1) and (9.4) and comparing them, we find the following relationship between the energy and momentum of a particle:

$$E^2 / c^2 = p^2 + (m * c)^2$$

Energy, expressed in terms of momentum, is called, as is known, the Hamiltonian function H:

$$H = c * (p^2 + (m * c)^2)^{0.5}$$

At low speeds $p << m * c$ and approximately

$$H \approx m * c^2 + p^2 / (2 * m),$$

that is, after deducting the rest energy, we obtain the well-known classical expression for the Hamilton function...”.

1. Hawking radiation. Wikipedia (ru). https://en.wikipedia.org/wiki/Hawking_radiation
2. Einstein, A. Does the inertia of a body depend on its energy content? Annalen der Physik 18 (1905).
3. Landau L. D., Lifshits E. M. Theoretical physics. Volume 2. Theory of the field. Moscow: Nauka. 1988. P. 45 – 46.